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NRL REPORT 4096

CATHODE-RAY-TUBE SIGNAL ACTIVITY RECORDER

H. K. Weidemann and J. S. Tomczak

Countermeasures Branch
Radio Division II

January 16, 1953

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NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

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ABSTRACT

The possibility of employing a dark-trace cathode-ray tube as a signal-activity recorder for use with microwave receivers has resulted in the construction of the necessary laboratory units capable of indicating some of the relative merits of such a device and perhaps disclosing possible physical difficulties inherent in its operation. A National Union NU-2112-E dark-trace tube was used in these experiments for recording the video output from an AN/APR-9 receiver. It was found possible to record readily pulse-signal bursts as short as 1/30 of a second while the receiver was continuously scanning in frequency. The record is clearly visible on a single scan, thus permitting the setting of the receiver frequency to the signal record and insuring a high probability of reception on succeeding bursts. It appears technically feasible to construct a recorder which could be used with receivers such as the AN/APR-9, AN/BLR-1, and AN/SLR. However, the physical problems encountered in the NU-2112-E dark-trace tube itself, many of which are common to other such tubes, indicate the need for considerable improvement in tube characteristics before this type of recorder can be seriously considered for field applications.

PROBLEM STATUS

This is an interim report; work on the problem is continuing.

AUTHORIZATION

NRL Problem R06-11
RDB Project NE 070-303

Manuscript submitted December 5, 1952

CATHODE-RAY-TUBE SIGNAL ACTIVITY RECORDER

INTRODUCTION

It is common knowledge that an operator who uses the AN/APR-9, AN/BLR-1, or AN/SLR receiver with a panoramascope indicator is attempting to recognize signals under trying conditions. Vigilance must be maintained under strain while watching the panoramascope screen for a signal burst; the ultimate goal is to stop the receiver tuning mechanism before the receiver tunes beyond the frequency of the signal. If the burst appears when the operator is momentarily distracted or if the signal is so short that it will not be readily recognized, then operator time and effort as well as a possible signal reception will be lost.

Two methods for overcoming some of these difficulties were suggested, and laboratory equipments were built to provide preliminary estimates of their value to the operators of these receivers. The first, known as Receiver Control C-719(XB-3)/APR-9,[1,2] is now being used experimentally in a special field operational installation. This device automatically stops the tuning mechanism of the AN/APR-9 receiver on the received signal frequency. It has a great value to the operator where the receiver tuning range contains a small number of signals. Verbal reports from operators using these controllers in field installations indicate that operation can become objectionable when many signals are present in the tuning range because the device stops the receiver on all signals present on every tuning scan. The second method utilizes an experimental signal frequency recorder, essentially adapting an old idea to a modern receiver.[3] This recorder employs a sparking pen that moves across the width of a long strip of Teledeltos recording paper. The pen position is servo-controlled by the tuning mechanism of the AN/APR-9 receiver. At the end of each tuning scan, the paper is advanced one line width. The received signals are registered as a density record with a position accuracy sufficient to permit manual tuning of the receiver to the signal frequency. No extensive evaluation of this device was performed, but it appeared evident that the major weakness was its inability to provide an adequate record on extremely short signal bursts. Since the recording mechanism is an electric spark, it

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1 Markell, J. H., "Interim Report on Airborne Automatic Search and Jam-Receiver Control C-719 (XB-2)/APR-9," NRL Ltr. Report C-3940-69/50 (Confidential), August 7, 1950

2 Markell, J. H., "Interim Report on Receiver Control C-719 (XB-3)/APR-9," NRL Ltr. Report C-3940-138/51 (Confidential), August 29, 1951

3 Misner, R. D., "A System of Signal Frequency Recording for Use with Radar Set AN/APR-9," NRL Report 3791 (Confidential), January 17, 1951

can be understood why, for short-duration signals, the record shows on the overlay paper as only one or two minute holes, the appearance of which is almost indistinguishable from the record made by receiver noise.

In contrast to the Teledeltos-type recording, a dark-trace tube operates with a minimum spot size which is visible to the eye. There was some reason to believe, therefore, that a signal-activity recorder employing such a tube would provide better performance on short signal bursts. Also, since the modern microwave receivers with which such a recorder might be used have slow scanning rates (i.e., one scan in approximately 45 seconds), it was believed that the limited writing rate of the dark-trace-tube screen would be more than adequate for such an application. This limitation would appear to be a minor handicap if the recorder were designed to register the pulse-signal-burst envelope instead of the individual pulses. Such a recorder would then be required to register burst-time rather than pulse-time duration.

To demonstrate the feasibility of the proposed type of performance, a laboratory recorder, utilizing a National Union NU-2112-E dark-trace tube, was assembled for experimental operation with an AN/APR-9 receiver. In this unit, as completed, the horizontal position of the cathode-ray-tube spot is controlled by the receiver tuning mechanism, and the vertical position is stepped downward approximately two line widths at the end of each scan. The video pulse trains from the receiver, as a result of r-f signal bursts, are fed into a pulse-peak envelope detector, the output of which is applied to the cathode-ray-tube grid to produce high-density spots on the cathode-ray-tube screen.

EXPERIMENTAL SETUP

Receiver Modifications Required

Figure 1 shows a block diagram of the experimental recording system used for these preliminary demonstration tests. An early prototype AN/APR-9 receiver was modified for operation with the recorder. These modifications consisted of (a) the installation of a linear wire-wound potentiometer (horizontal potentiometer) mechanically linked to the tuning mechanism and mounted on the r-f tuner, and (b) the installation of the necessary additional electrical connections (from relay K-902, etc.) from the sector-tuning control system in the AN/APR-9 power supply. This change was made to provide a control voltage for step deflection of the cathode-ray-tube spot at the end of each tuning scan. The video signal from the receiver (video line) is the normal wideband video output, and it is thus possible for a pulsed r-f signal to provide an output for any signal frequency within the 20-Mc passband of the receiver. The frequency resolution is then no better than approximately 20 Mc, which is about one percent of the total frequency scan for the tuning head covering 2300 to 4450 Mc.

Frequency-Scan Display System

To provide a horizontal time scan synchronized with the receiver tuning mechanism for the cathode-ray-tube spot, a dc potential is applied across the horizontal potentiometer, which in Figure 1 is shown mechanically linked to the receiver tuning head. The output from the moving contact of this potentiometer is amplified in the horizontal deflection amplifier which is direct-coupled to the electrostatic horizontal deflection plates of the dark-trace tube. Using a conventional cathode-coupled push-pull output circuit, this deflection amplifier was designed around a

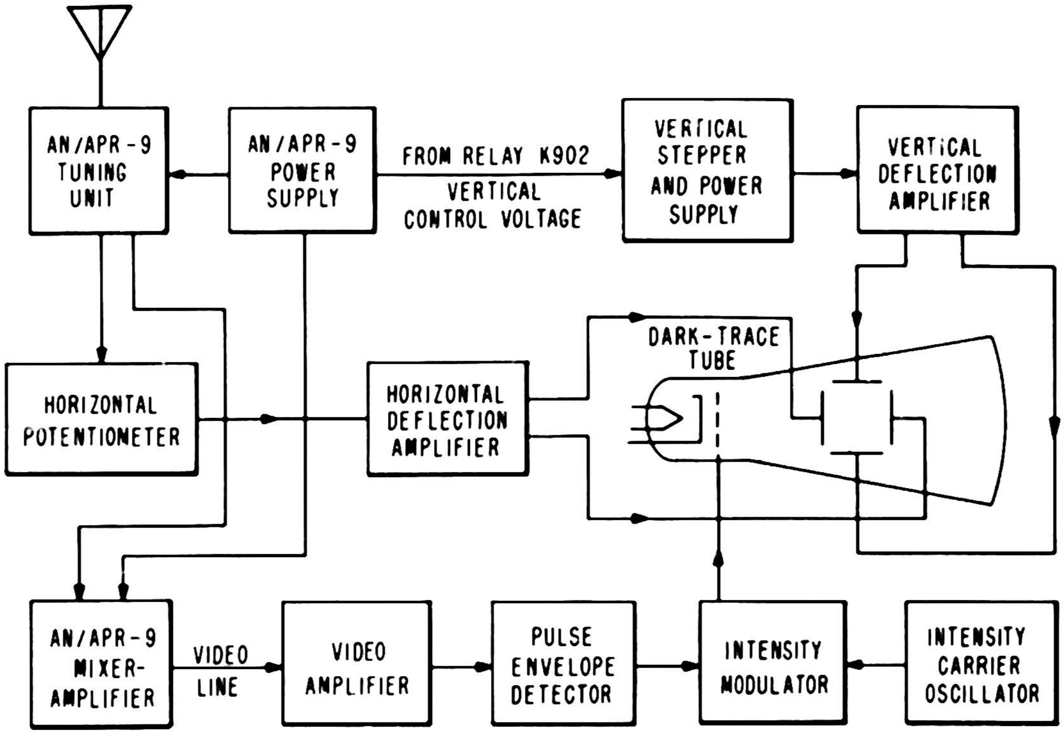

Figure 1 - Block diagram of recorder system

12AX7 dual triode. The high deflection factor of the cathode-ray tube makes it necessary to operate this dual triode considerably beyond its potential difference rating to achieve adequate deflection. Fortunately, therefore, the upper frequency response required in this amplifier is less than 20 cps. Since relatively large loads may be used, the experimental operation of the stage is relatively safe between the supply potentials of +500 volts and -150 volts. In the event of internal shorts within the tube, the large load resistances provide adequate protection to the power sources. This amplifier also provides convenient means for gain and centering controls. It should be noted that this method of deriving spot deflection from the receiver tuning mechanism automatically limits the deflection to a range directly related to the settings of the receiver sector-scanning controls.

Raster-Time Display System

The vertical progression of the frequency-time raster developed on the face of the cathode-ray tube is produced by a potentiometer and deflection amplifier that is similar to the system used for frequency-scan deflection. Here, however, the potentiometer motion is discontinuous and advances by a small increment each time the frequency scan reverses. The circuitry and mechanism for generation of this stepping function are represented in Figure 1 as the block-labeled vertical stepper and power supply. The pertinent details of the stepping system are shown in Figures 2 through 4. Figure 2 indicates the point within the AN/APR-9 power supply from which the stepping control is derived. In the AN/APR-9 receiver, K902 is a relay which is closed during automatic frequency scan in one direction and open during scan in the opposite direction.

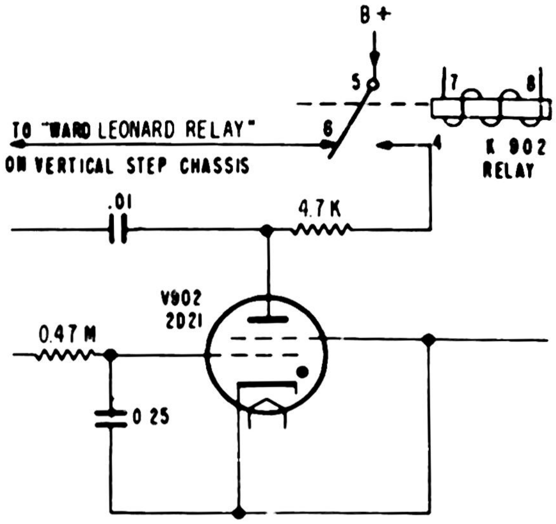

Figure 2 - Circuit showing K902 in AN/APR-9 power supply
(Handbook of Operating and Maintenance Instructions for Radar Set AN/APR-9 (XN-1) Report No. 115-1, January 1948

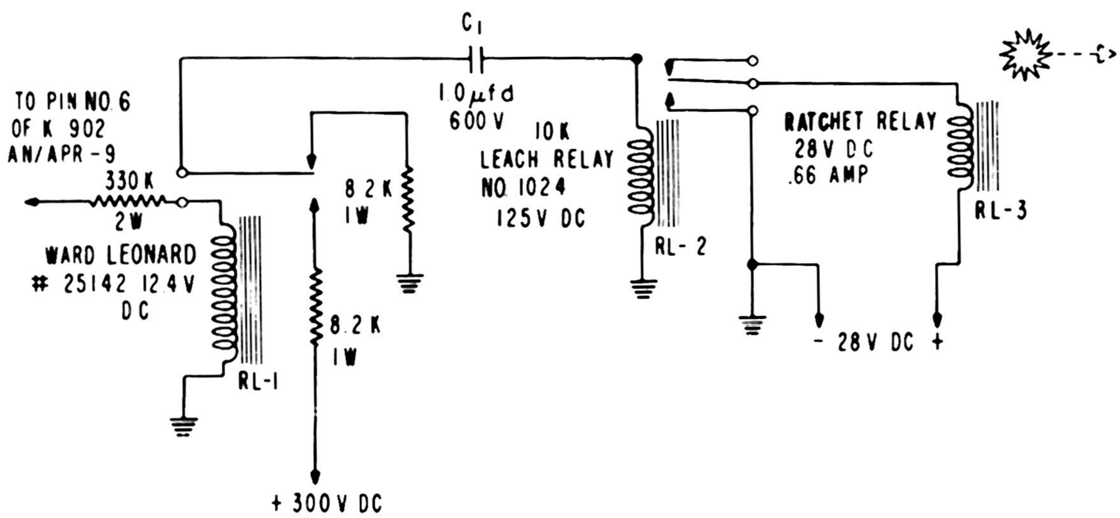

Figure 3 - Control relay circuits for vertical stepper

Pin 5 on the relay contacts is connected to a source of positive potential, but Pin 6 is normally not used in the receiver circuitry. A lead connected to Pin 6, therefore, can deliver to an external circuit a square-wave potential-time function which rests at zero potential while scanning in one direction and at a fixed positive potential for the reverse scan. Figure 3 shows how this square-wave control potential is utilized to provide a unidirectional stepping scan potential for the raster display. The waveform from Pin 6 of K902 energizes RL-1 during scan in one direction and permits it to be de-energized during reverse scan. When RL-1 is energized, C1 is charged to a potential difference of 300 volts through the front relay contacts. During the reverse scan, C1 is

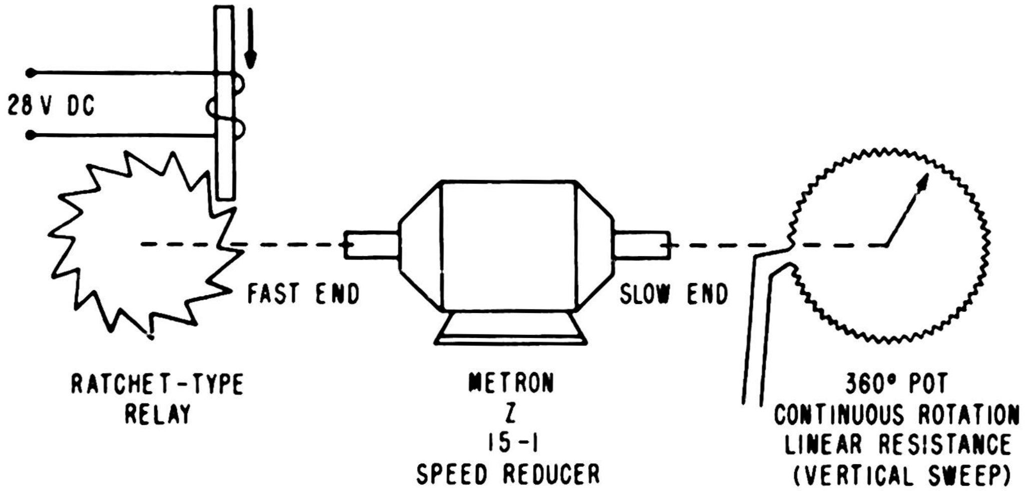

Figure 4 - Schematic of vertical sweep stepper

discharged through the back contacts of RL-1. The time constants for charge and discharge are controlled by the 8.2-kilohm resistors so that the charge and discharge current pulses through RL-2 are of sufficient duration and adequate magnitude to close its front contacts long enough to insure the complete function of the ratchet relay, RL-3. Figure 4 indicates how the ratchet-relay mechanical output is geared to a 360-degree potentiometer from which is derived the cathode-ray-tube vertical-deflection potential difference. Through these devices, the arm of the potentiometer is made to move in one direction by a fixed mechanical increment each time the receiver reverses its direction of frequency scan. Figure 5 shows the manner in which the cathode-ray spot moves during the development of a complete raster as the result of the automatic operation of the receiver frequency-scan system. For clarification, the vertical step has been shown exaggerated in relative amplitude.

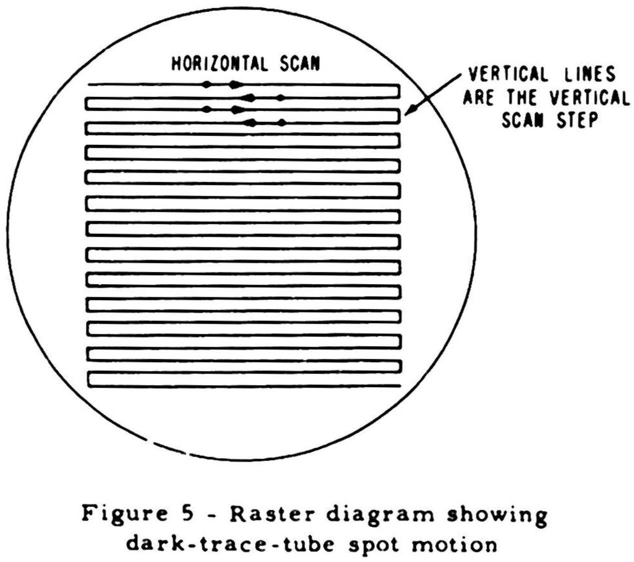

Figure 5 - Raster diagram showing
dark-trace-tube spot motion

Video Display System

The signal wideband video output from the AN/APR-9 (Figure 1) is employed to provide a density record on the cathode-ray-tube screen; the position of this output on the horizontal scan is indicative of the radio frequency on which the signal is received. To provide an indication based on signal burst time rather than signal pulse duration, the receiver video output (video line) is amplified in a conventional video amplifier, the output of which is fed into a pulse envelope detector. For simplicity this envelope detector consists of a conventional pulse-peak detector with a long decay time compared to the lowest pulse repetition period to be considered (i.e., 500 pulses per second). No effort was made in this experimental equipment to design the detector for operation with pulses less than one-microsecond duration or repetition rates less than 500 pulses per second. Within the design restrictions, the output of the envelope detector is a dc potential, the magnitude of which is directly related to the pulse peaks within the received pulse train. Since the potential difference between the cathode-ray-tube intensity grid and the output of the envelope detector amounts to several kilovolts, direct coupling of these points, although desirable, is not easily achievable.

To provide all the advantages of direct coupling for the cathode-ray-tube intensity grid and at the same time to permit the employment of capacitive coupling, the output from the envelope detector is used to amplitude modulate a carrier frequency. The modulated carrier is applied through a small coupling capacitor to modulate the intensity of the cathode-ray-tube beam. This modulation is accomplished by direct-coupling the envelope-detector output to the suppressor grid of a 6AS6-type tube (intensity modulator). Since the envelope waveform increases in amplitude in the positive-potential direction, the normal bias for this grid is adjusted to approximate plate-current cutoff. A symmetrical free-running multivibrator (intensity carrier oscillator) is coupled to the control grid of the 6AS6 tube to provide carrier-current pulses at a frequency between 15 and 20 kc. With this system, it is possible to tune the receiver to a continuous pulsed signal and produce a continuously sustained intensification pulse.

EXPERIMENTAL EQUIPMENT

The laboratory equipment which was constructed for experimental testing appears in Figures 6 through 9. Figure 6 shows the potentiometer which was geared to the countershaft of the tuning head to provide the horizontal sweep potential synchronized with receiver tuning. Figure 7 presents the assemblage of relays, gear box, and a 360-degree potentiometer used to provide the stepping potential required in generating the time dimension (vertical sweep) of the frequency-time raster. It will be noted that one additional relay appears in Figure 7 as compared to Figure 3. This additional relay is controlled by the cam switch on the potentiometer shaft to stop the vertical scan at the bottom of the raster, thus permitting erasure before beginning a new raster.

Figure 8 is a front view of the dark-trace-tube chassis and its power supply. In Figure 9 the tube chassis is shown in three-quarter view where two of the three connections can be seen entering through holes in the shield to the cathode-ray-tube screen and erase filament terminals of the National Union NU-2112-E dark-trace tube. In the center foreground can be seen the video amplifier, envelope detector, and intensity-pulse modulator. The small vertical chassis near the right rear of the main pan provides mounting space for the horizontal and vertical sweep amplifiers. The ventilated black box in the rear is a radio-frequency high-voltage supply providing about nine-kilovolts accelerating potential for the cathode-ray tube.

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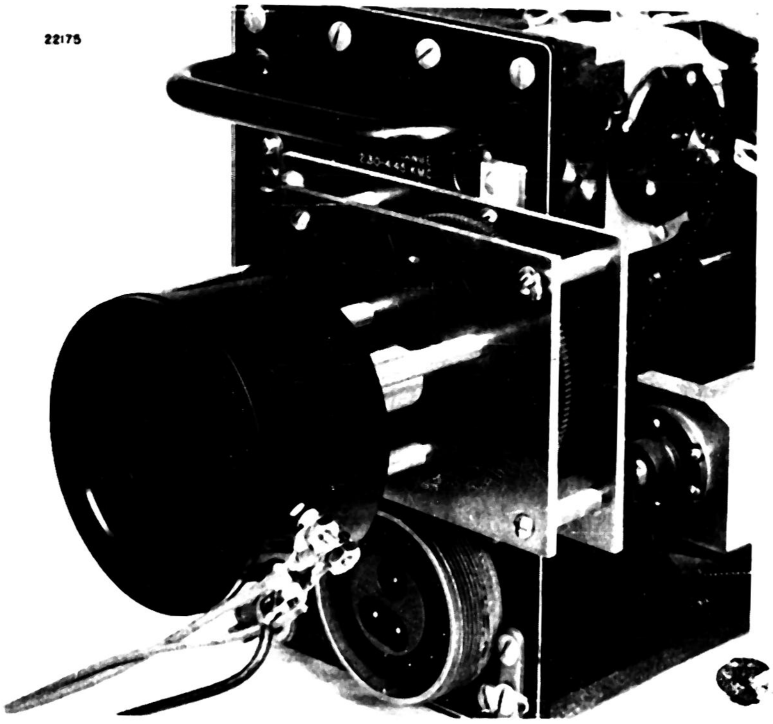

Figure 6 - Horizontal sweep potentiometer mounted on AN/APR-9 tuning unit

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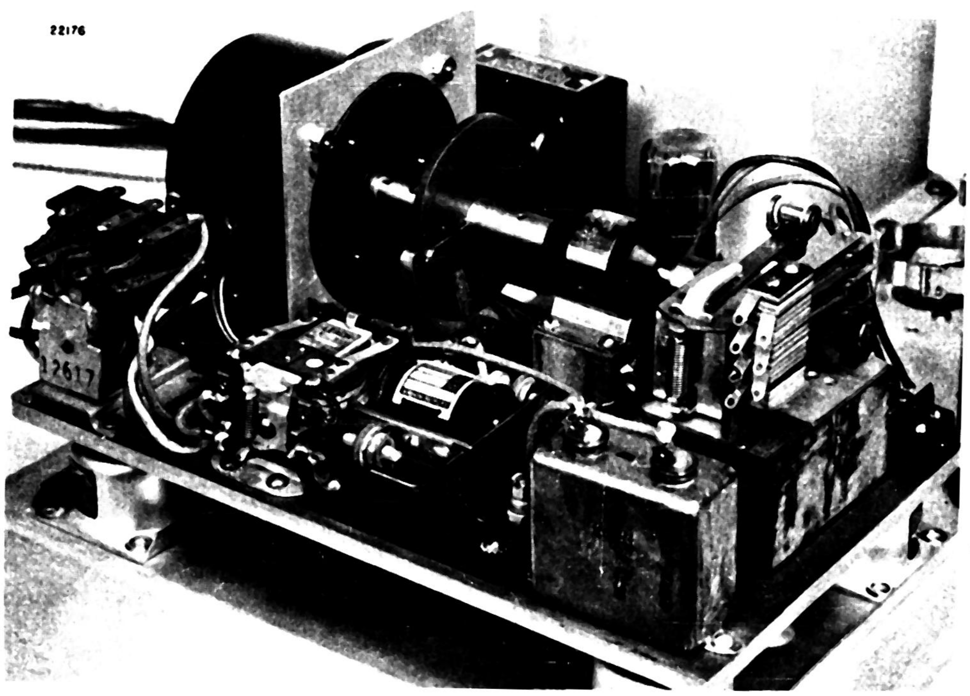

Figure 7 - Vertical stepper relays and mechanism

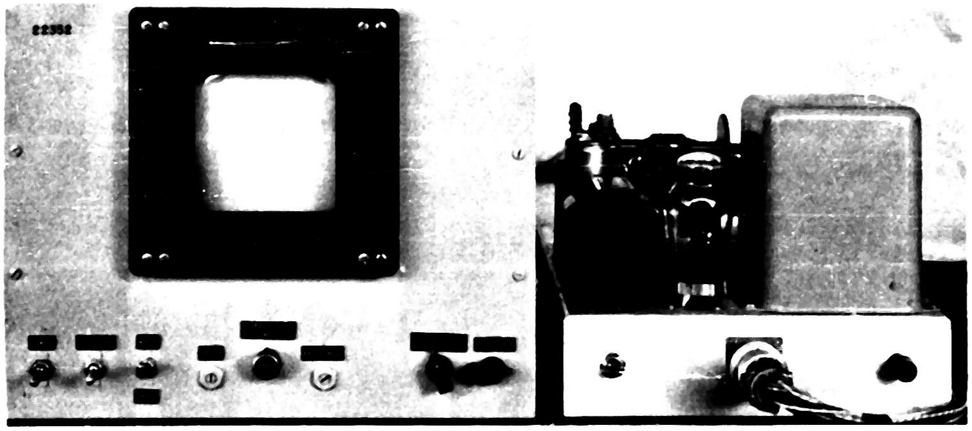

Figure 8 - Front view of dark-trace-tube chassis and power supply

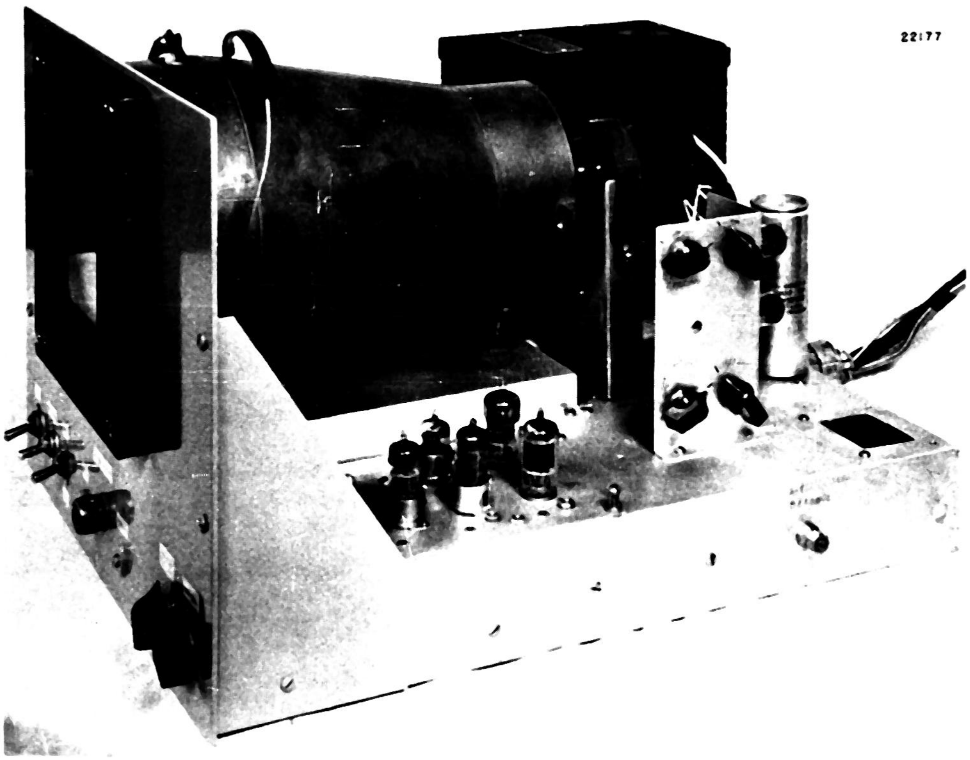

Figure 9 - Right side view of dark-trace-tube chassis

CATHODE-RAY-TUBE CHARACTERISTICS

The National Union NU-2112-E dark-trace cathode-ray tube was originally constructed at the request of this Laboratory as a modification of the 7JP4 cathode-ray tube as used in early television receivers. The electrostatic gun structure and deflection plates of the 7JP4 tube were retained whereas the P4 phosphor was replaced by a thin glass film upon which the potassium chloride was evaporated. Just in back of this screen is mounted a directly heated thin-wire filament suspended on small insulators. This wire forms an open grid structure which can be heated by current conduction to provide a large effective area of electron emission capable of producing a relatively uniform electron bombardment of the potassium chloride screen. The number and size of the wires in the emitting grid is so small that no serious shadow is presented on the potassium chloride screen when a sharply focused beam is used for writing. During erasure the grid is brought to emission temperature and a fixed potential difference is applied between the potassium chloride screen and the emitting grid. The resulting energy of electron bombardment on the screen successfully erases the previous record in 10 to 15 seconds. The total power required in the erasure circuits is approximately 220 watts. Of this total, 145 watts are consumed in the emitting grid, and the remainder is applied to accelerate the bombarding electrons.

This screen structure and erase system was developed by the National Union Radio Corporation under a Bureau of Ships contract. The rapid erasure achieved is in part due to the use of a thin glass film upon which the potassium chloride is deposited; a screen structure with low thermal inertia is thus provided. It is to be noted, also, that the achievement of a low thermal inertia structure results in a screen which is rather easily damaged by overexcitation during the recording process. Prevention of overexcitation requires the use of rigidly limited intensity-pulse amplitudes, careful adjustment of both the focus and intensity bias potentials, and a high-potential source which is free of large power transients.

The National Union specification for this tube permits the use of a maximum acceleration potential difference of ten kilovolts; this total difference should provide no more than six kilovolts across the gun structure with the remaining four kilovolts applied as a post-deflection accelerating field. In this application, the use of direct coupling to the deflection plates requires a choice between applying all the accelerating potential difference across the gun structure and constructing an erase power system to permit operation around a mean potential difference several kilovolts above ground. To avoid the use of special transformers and the complication of a complete erase chassis operating several kilovolts above ground, both the deflection structure and the erase circuitry in this experimental equipment were referenced within a few hundred volts above ground. In addition, practically all of the accelerating potential difference was applied across the gun electrodes.

Operating this tube under the preceding conditions makes it necessary to exceed the maximum potential difference permitted across the gun structure since satisfactory writing on the screen requires a minimum total accelerating potential difference of at least seven kilovolts. For the records shown in this report, this potential difference was held at approximately nine kilovolts. The resulting surface-leakage problems in the tube socket were annoying on days when the humidity was high.

In the first tube used, an internal arc developed in the gun structure and prevented operation above seven kilovolts. The second tube, however, functioned successfully over a period of months at potential differences up to ten kilovolts; final failure was caused by an open heater circuit. The third tube was used under similar conditions for only a

short period near the end of the experimental work and was still operable at the time this report was written.

The use of acceleration potentials of the order described, where no post acceleration is used, results in electrostatic deflection factors in this tube of the order of 250 to 350 volts per inch. Since high-frequency response is not a problem for the deflection amplifiers required in this application, it is embarrassing to find no low-power miniature tube, such as the 12AX7, which will deliver the necessary potential excursions without exceeding the maximum potential difference permitted by the tube ratings.

Throughout the period of operation of this experimental setup, corona in the voltage-divider network for the cathode-ray-tube gun has been a continuing problem, varying in severity with daily changes in weather. On unfavorable days arc-overs occurred owing to corona build-up; as a result, power transients almost invariably resulted in damage to the screen material. For sea-level installations, this condition can undoubtedly be overcome with ease, but it demonstrates the nature of the problem inherent in this type of recorder and possibly indicates such a device to be impractical for high-altitude performance.

It is interesting at this point to note that in this application the use of electrostatic deflection is not a requirement since the sweep times are so long. The use of magnetic deflection would apparently permit some additional flexibility in cathode-ray-tube circuit design. However, any distribution of total acceleration potential difference which places the erase circuitry at or near ground potential will result in large potential difference between the cathode and ground. As a result, special handling will be necessary to minimize corona and the possibility of occasional arc-overs.

EXPERIMENTAL RECORDS

Controlled signal bursts having a known burst-time length were recorded with the experimental setup as described. For these tests, the recorder was connected to the AN/APR-9 video output, and pulsed r-f signals were fed into the receiver antenna jack from a Hewlett-Packard 616A microwave signal generator. To provide known pulse-train times, the signal generator was externally modulated by an intermittent signal-simulator equipment.[4] In addition, some tests were run with received pulsed signals from local radars operating at the National Airport and within the area of the Naval Research Laboratory.

Since these tests are intended to provide only a preliminary assessment of the dark-trace-tube's ability to record short signal bursts, no measurements were made of minimum signal levels required for recording as a function of pulsewidth or frequency. Experience with envelope detectors indicates that they can be made to function almost independently of pulsewidth and pulse frequency over relatively wide ranges if the detector is designed with adequate reserve power to provide a rise time less than 1/10 microsecond followed by a decay time constant which is long compared to the longest pulse period to be integrated. Use of a properly designed detector would seem to make burst-time duration the most important factor that controls recording density. For the laboratory-controlled tests, the pulsewidth was approximately two microseconds and

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4 Tool, A. Q., "Intermittent Signal Simulator for Intercept Equipment Testing," NRL Report 3663 (Restricted), May 17, 1950

the repetition rate was set at approximately 1500 pulses per second. For all the records shown, the receiver gain was set high enough to insure a background density which was controlled by receiver noise level rather than intensity grid bias. The records, therefore are signals on a noise background. No measurements, however, were made of the minimum signal-to-noise ratio required for a minimum visible recording. All controlled signals were set at a level adequate to drive the cathode-ray tube to maximum recording density for a continuous signal. The only variable-signal parameter then considered is variation of signal burst time.

The records shown here are samples with adequate density to permit production of relatively good photographs. Preliminary laboratory experience with this type of record indicates, qualitatively, that much smaller density variations in the record can be detected by visual inspection than can be photographed with the equipment on hand.

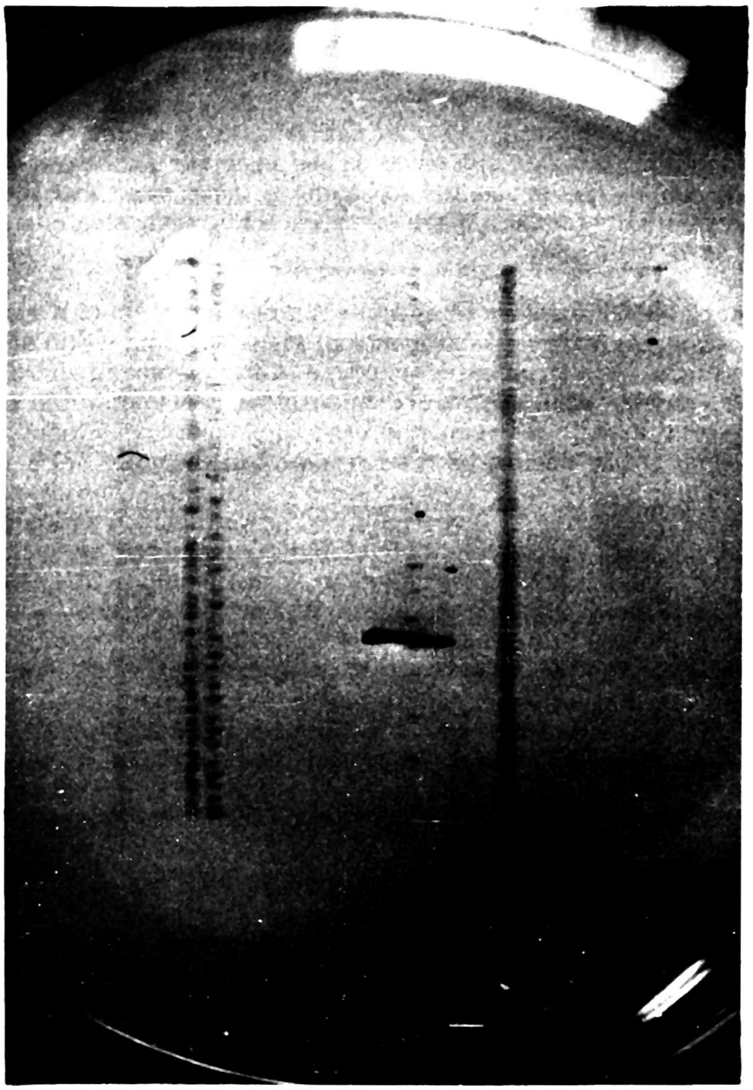

Figure 10 - Full-raster record

FULL-RASTER RECORD

Figure 10 shows the dark-trace-tube screen after recording a full raster with the AN/APR-9 receiver scanning the full spectrum from 2300 to 4450 Mc. Signal frequency is represented by horizontal displacement, and low-to-high frequency progresses from left to right. Increasing raster time advances from top to bottom.

The raster as shown measured about 2-3/4 inches high by 2-5/8 inches wide; approximately 32 horizontal scan lines per vertical inch appeared in the mid-portion and each was recorded in approximately 45 seconds.

For this record, an antenna and a laboratory signal generator were connected to the receiver. A record of a continuous pulsed signal was provided by the signal generator for comparison with records developed by signals received from radar systems in the immediate area. The two parallel records at the extreme left of the raster (Figure 10) represent the two radars at the Washington National Airport that are used to provide air surveillance. The steady-signal record on the extreme right was made by the laboratory generator. Between these extremes can be seen a faint, intermittent recording which was, apparently, a rotating radar of rather narrow effective beamwidth. This equipment was not identified but was observed on the receiver panoramascope as a relatively weak signal which was presented for such a short time that the flash appeared almost stationary on the indicator time base even when the reception occurred while the receiver was scanning in frequency.

This raster record has interest primarily as a demonstration of a range of performance which could probably be expected on practical signals. The width of the record for the continuous pulse signal is somewhat descriptive of the passband width of the 160-Mc i-f amplifier in the receiver. The record for this signal represents the maximum which can be expected since the signal was recorded for a time interval of about 1/2 second on every frequency scan. The record on the extreme left is typical of a radar having a low antenna-rotation rate, high power, and relatively wide effective intercept beamwidth. The rotation rate is of the order of three rpm. The beamwidth is known to be approximately one degree in azimuth, but because of the high transmitted power and relatively short range to the radar, the signal reception time is of the order of 1/2 second. If a long run of coaxial cable having considerable attenuation had not been used to connect the receiver to the remote antenna, this signal would have been received almost continuously. In contrast, the next record to the right is for a radar rotating at 30 rpm with a beamwidth of the order of three or four degrees. This signal was a periodic flash lasting only a few tenths of a second. The intermittent record in the middle of the raster represents a signal from an unidentified source and is probably typical of performance for cases where the reception probability is low. From the record, it can be seen that successive receptions were typically separated by time intervals up to four or five minutes. This signal represents a case in which an operator will find it difficult to set on frequency if only the panoramascope is available as an indicator.

The scar in the lower center of the raster is typical of the damage which can result in destruction of the screen. This damage occurred during one of the preliminary recordings and while the equipment was not under direct observation. The exact cause was not determined. The other three small dark spots above and to the right were burned into the screen owing to arc-overs in the cathode-ray-tube bleeder as a result of corona discharge. None of these burned spots occurred during the production of the record shown in Figure 10.

FLASH-SIGNAL RECORDS

To demonstrate the ability of a dark-trace-tube recorder for registering signals that have short "flash" duration times, a record was prepared and photographed for a repetitive pulse-train signal where the time length of the pulse train was set to a value of approximately 1/30 of a second. In this instance, the Hewlett-Packard 616A signal generator was externally modulated by the intermittent signal simulator, [4] and the signal-generator output was fed to the receiver antenna input jack on the AN/APR-9 receiver. The pulsewidth and frequency were adjusted to the same values used for the record in Figure 10, and the simulator was set to deliver pulse trains approximately 1/30 of a second in length at a rate of about one train every two seconds. To further increase the probability of signal reception during receiver frequency scan, the re- receiver sector-scanning controls were set for minimum sector width, which included the signal frequency. Under these conditions, successful signal records appeared on a majority of the frequency scans (Figure 11).

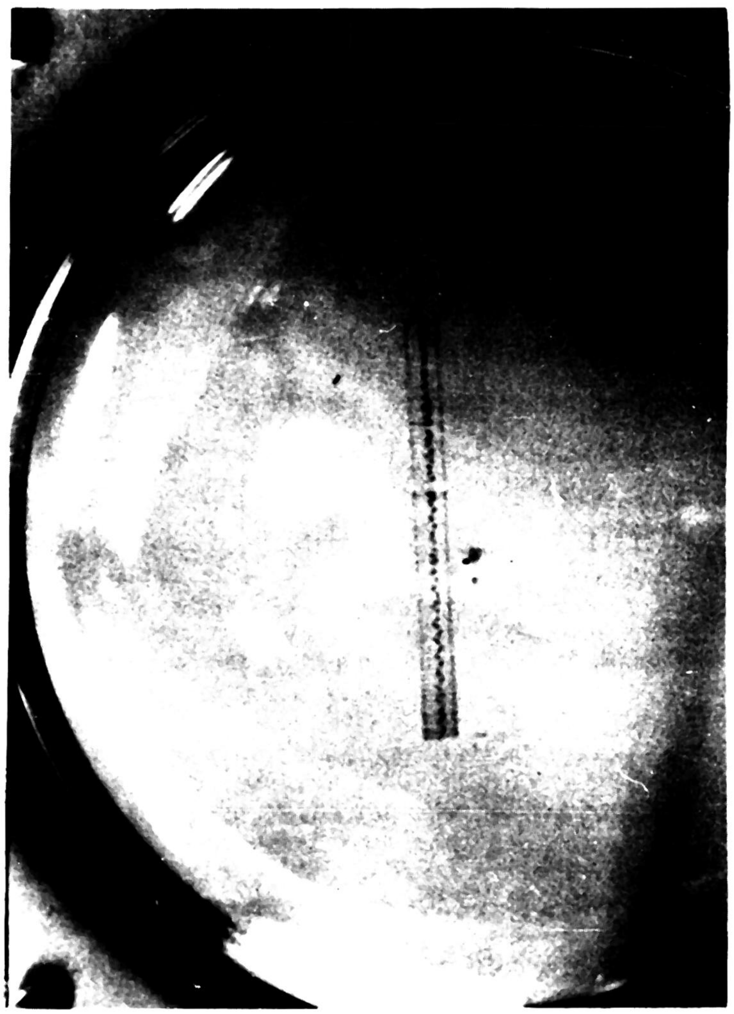

Figure 11 - Sector scan record showing a signal flash lasting 1/30 of one second every two seconds

Comparison of the record shown in Figure 11 with that for a continuous signal in Figure 10 shows that the signal flash time as shown in Figure 11 is short compared to the approximate 1/2 second during which a continuous pulse signal is within the receiver passband when the receiver is scanning. In fact, the record for each signal burst appears to be approximately as wide in the scan direction as the cathode-ray-tube spot diameter.

The data related to Figure 10 permit a rough estimate of the cathode-ray-tube spot diameter. Since the full raster contains approximately 32 lines per inch in the vertical dimension, the lines in the middle of the raster (Figure 10) are spaced approximately 0.031 inch apart. Inspection of the record for a continuous signal indicates the line width to be about one half the line separation so that a crude estimate indicates the spot diameter to be of the order of 0.016 inch. In addition, it is known that a raster width of 2.63 inches is scanned in 45 seconds. Since the signal is presented for only 1/30 second, the spot center moves in this time along the width dimension a distance of the order of 0.002 inch* (i.e. 2.63/30X45). Comparing this calculation with the estimated spot diameter, spot motion amounts to approximately 1/8 of one spot diameter for signals bursts of only 1/30 second duration. It appears, therefore, that the density of records produced for shorter signal bursts will depend almost entirely upon the transient time required to record a single motionless spot rather than upon the ability to record a line with the spot in motion. No effort was made in these preliminary experiments to determine quantitatively the absolute recording threshold as a function of flash-time duration. Subjectively, it appears fair to say that the density of the record in Figure 11 compares favorably with that shown in Figure 10. Since signal bursts as short as 1/30 of a second are relatively rare even in the microwave spectrum, the performance shown in Figure 11 indicates that a dark-trace tube would be a successful recorder for short-duration signals likely to be encountered in practical field operations.

OTHER CONSIDERATIONS

Before this recording technique can be evaluated for possible practical applications, additional factors should be considered.

First among these considerations is the fact that this recording technique like that of Reference 3 is capable of daylight viewing. In some applications this may be a definite advantage, but where it might be desirable to attempt integration between the operation of this device and the operation of indicators and analyzers based upon cathode-ray tubes employing fluorescent phosphors, a problem of satisfactory illumination of the recorder screen would require solution.

Second, since the potassium chloride screen in this tube is mounted well behind the front surface of the cathode-ray-tube glass envelope, it would be relatively impractical to employ direct-reading frequency scales external to the envelope because of the large amount of parallax which would exist between the scale and the record. This difficulty might be overcome by the use of a scale-image projection scheme, designed to place a virtual image of the scale on the plane of the screen.

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* In this calculation, it is assumed the horizontal deflection amplifier is reasonably linear throughout its deflection range. This assumption is not entirely valid here since it is known that the amplifier was driven close to the maximum excursion in each direction.

A third factor noted during laboratory observations is the problem of interfering reflections from the surfaces of the cathode-ray-tube envelope. The highlights in both Figures 10 and 11 are indicative of this problem. In many cathode-ray-tube indicators employing fluorescent phosphors, this problem is greatly alleviated by the use of Plexiglas color filters in front of the display. Since such a scheme is not feasible with a dark-trace-tube display, it might be possible to improve the conditions of viewing by treating the envelope front glass surface with a coating similar to that used on coated lenses to reduce surface reflections and improve the over-all transmission efficiency.

A fourth consideration arises from the eventual possibility of redesigning the tuning-mechanism control system in microwave superheterodyne receivers to provide for frequency scans at the rate of approximately one scan per second in receivers such as the AN/APR-9.[5] If such redesign does eventually appear both feasible and desirable, a dark-trace-tube recorder may not be suitable for use with such a scanning system because of the considerable time required for erasure at the end of each raster. It should be noted here, also, that the recording system described in Reference 3 would probably not be satisfactory with a receiver having this order of scanning rate, since the mechanical servo system for the pen-position control would not be sufficiently rapid in its response to provide the required accuracy of signal-frequency recording. A more suitable device for such a rapid scanning receiver may possibly be achieved by designing a raster presentation around a P7 phosphor[6] or through the use of longer persistent phosphors. This material has been reported to NRL by the Allen B. Du Mont Laboratories as available in experimental cathode-ray tubes under an experimental phosphor performance specification described on Du Mont data Sheet No. TL-1122.

CONCLUSIONS

The experimental recorder described in this report has demonstrated that a signal-activity recorder for use with microwave receivers such as the AN/APR-9, AN/BLR-1, and AN/SLR is technically feasible under laboratory conditions. It has been shown that such a recorder can successfully register a flash signal having a burst time as short as 1/30 of a second. This record identifies the signal frequency on the scan display with an accuracy that permits the receiver to be set to the signal frequency.

Although the NU-2112-E dark-trace tube was successfully used in these experiments under laboratory conditions, it is not suitable for field applications in its present form. The erase circuitry required for this tube complicates the arrangement of acceleration fields for the cathode-ray-tube beam. As a result, it is necessary either to isolate the erase circuitry so that it will operate several kilovolts above ground potential or to assign nearly all of the acceleration potential difference to the cathode-ray-tube gun structure. The use of this arrangement simplifies the erase circuitry at the

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5 Weidemann, H. K., "Universal Intercept System - General Considerations Governing the Design Problems Encountered in Frequency Scanning Receivers," NRL Ltr. Report C-3940-46/52 (Confidential), April 18, 1952

6 Beck, H. M., "Time Sequential Frequency Indicators," NRL Report 3644 (Restricted), March 30, 1950

expense of increasing the electrostatic deflection factors beyond the limits which are practical for deflection amplifiers designed around low-power dual triodes now available.

Laboratory experience has shown that the NU-2112-E dark-trace screen is relatively fragile compared to conventional cathode-ray-tube fluorescent phosphors. The low thermal inertia of the potassium chloride screen structure promotes rapid erasure and apparently makes the screen susceptible to spot burning. Such damage can be caused by momentary power-supply transients or excessive potential on the intensity control grid due either to improper grid-bias setting or to the application of high-energy signal pulses.

The relatively high accelerating potential differences required for the proper operation of a dark-trace tube require special care in circuit arrangement to minimize corona and surface-leakage currents. Such circuitry can be achieved for operation of these tubes at or near sea level. It is questionable, however, whether adequate control of these factors can be achieved at high altitudes without the added complication of pressurizing the cathode-ray-tube circuitry.

In the particular application described in this report, the use of electrostatic deflection is not necessarily an advantage. The required sweep speeds for the display could be readily achieved by using a conventional type of magnetic deflection system.

In the experimental recorder, the erase time represents a small fraction of the total raster time (i.e. 10 to 15 seconds as compared to approximately two hours); consequently erase time is negligible as a practical consideration. If, however, the raster were developed at a rate of the order of one frequency scan per second and should produce a complete raster in two or three minutes, it is questionable whether the erase time now provided could be considered short enough. Under this condition, the use of either a P7 phosphor or a fluorescent phosphor of longer persistence, if available, might prove to be a better choice.

RECOMMENDATIONS

Because of the limitations described, it is not recommended at this time that a dark-trace-tube signal activity recorder be considered for field applications.

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